SECRET PROGRESS REPORT

Period of June 1 to June 30, 1963

Contract No. AF33(600)40280

TABLE OF CONTENTS

SECRET

A FLIGHT TEST

GENERAL

Several successful high altitude-supersonic flights were made this month. All modes of motion compensation were used and the newly installed recorder film speed control was tested.

Frequencies up to 300 cps have been detected in primary film recordings of holograms and function generator tests. The highest frequency detected visually during a frequency response test is 500 cps.

Some identified targets on the correlated film are the Pentagon and its south parking lot, the Census Bureau Building in Washington, Washington National Airport, the towns of Chambersburg, Pennsylvania and Frederick, Maryland, railroad lines and highways. Examples of resolution are 5 mil (26 feet) azimuth spacing between rows of cars at the Census Bureau parking lot, and 5 mil (15 feet) range dimension of roads.

FILM EVALUATION

Primary Film - Changes in system offset frequency are discernable on the primary film by changes in the registered video level and the "oatmeal" frequency. As the offset frequency increases, the "oatmeal" frequency increases. As this frequency goes up, it approaches the limit of the eye first and then the recorder band-pass reducing video amplitude.

Non-uniform range focus existed on several flights this month. This condition was extremely bad in the near range sector, less severe in the far range sector, but not bad enough

SECRET

to prevent data correlation. It has been determined that this focus problem was caused by misadjustment in the CRT mounting.

A vibration resonance exists in the recorder. A 175 to 200 cps vibration striping can be seen in the near range sector of the film, and a 300 cps striping can be observed in the far range sector. However, when low frequency video is recorded in the far range sector, the striping is masked by the higher magnitude video.

Most video recorded was characteristically high in frequency indicating a high offset. However, many zero type holograms were recorded. Comparing these holograms with their correlated dots indicates zero holograms are caused by targets such as buildings, bridges, towers, and extremely strong radar targets which is normal. In most cases, the zero holograms had high trailing frequencies and very low or zero leading frequencies.

Typical range dimension for holograms is 5 mils, and 300 cps can be seen in the hologram. Typical dot size in "oatmeal" video is 2.5 mils, representing range dimension of 15 feet.

Correlated Film - Identified targets include Friendship Airport, bridges, parts of Westinghouse Defense Center, small towns, railroad lines and many secondary roads. Field patterns are defined by varying gray levels as well as natural and man-made borders.

The B & O Railroad line into Gaithersburg, Md., appears as a bright line of video. RF return from tracks and roadbed is higher than adjacent terrain.

Spacing between rows of cars on the Pentagon south parking lot is 7 mils corresponding to 36 feet. Each wing of the Census Bureau Building in Washington is resolved with 25 mils (75 feet) range separation. This dimension measures 50 feet on a Geological Survey Map.

Many dots with 5 to 10 mil diameter are registered on film. These dimensions correspond to 15 to 30 feet in range and 25 to 50 feet in azimuth. However, some distortion of dots exists; at various times the distortion appears as a range stretching, an azimuth stretching or a combination of both. Close study of instrumentation data, hologram characteristics, and signal strength has failed to reveal the cause of this distortion.

The effects of too low an offset frequency are made clear by two specific examples. Near the end of flight S-65 the signal-to-noise ratio increased; instrumentation recordings showed an increase in offset frequency. Also, several large targets have a strong leading "feather". The holograms which produced these dots pass through zero with approximately 150 cps in the leading edge. In the correlation process, it is impossible to focus both sides of a hologram, and since the radar and correlator were set up to focus low to high frequency holograms, this high frequency leading edge is not focused and is smeared on the correlated picture. Increasing the offset frequency would improve this situation, but the high frequency end of the offset is limited by recorder band-pass.

INSTRUMENTATION

Magnetic instrumentation configuration has been modified for "quick-look" data; an example of the recording is shown in Figure 1. This recording is prepared by transcribing in-flight magnetic tape recordings on paper through an ink recorder.

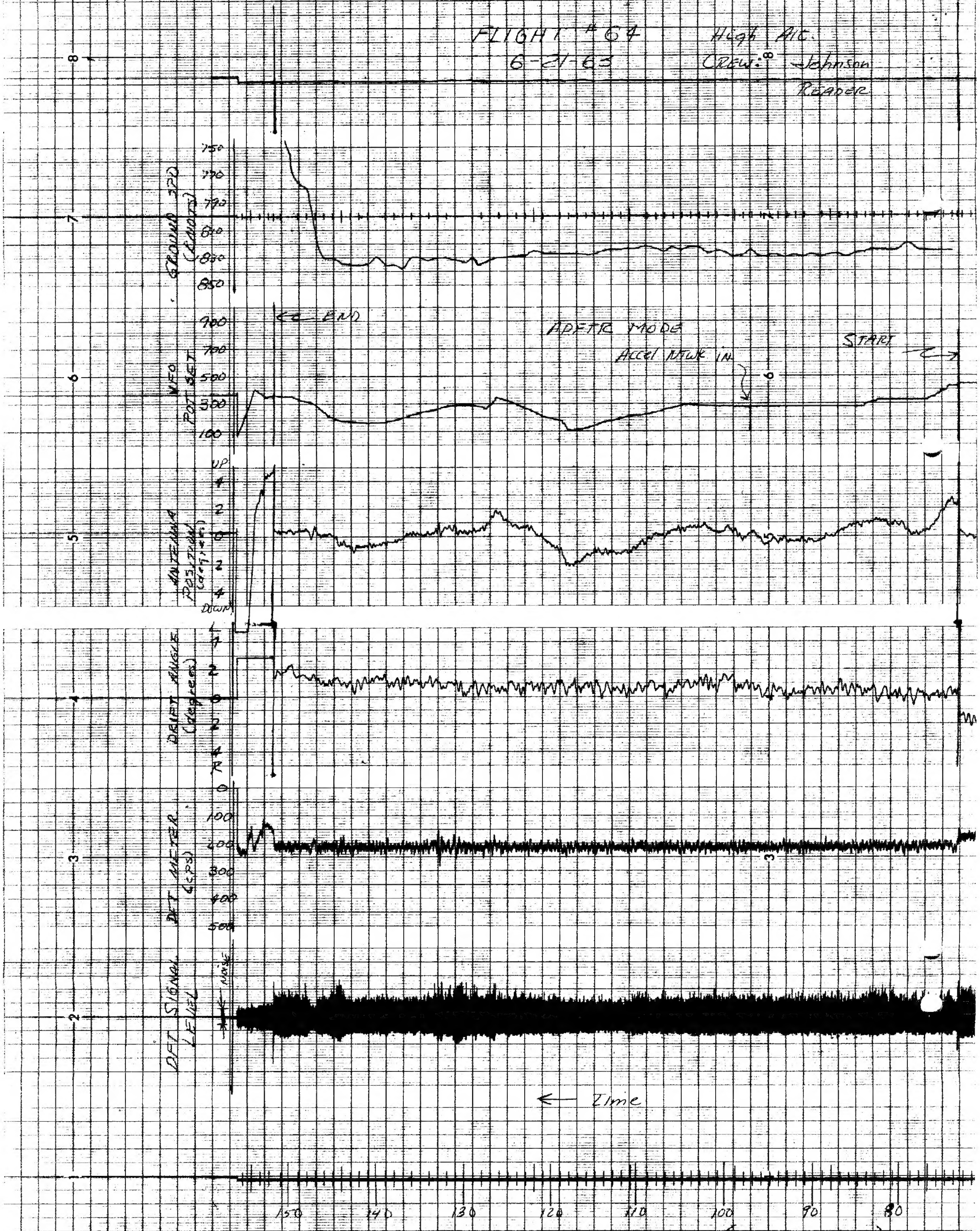
Instrumentation recordings indicate some difficulty in obtaining and maintaining DFT lock-up caused by aircraft accelerations. Steps have been taken to minimize the acceleration.

SYSTEM

The recorder variable film speed control was tested by comparing plots of aircraft ground speed with the distance between data flashes. The data flash timing device was set for 4.99991 seconds per flash. A constant ratio of 1:127.5 exists between the data flash interval and ground speed, indicating the film speed control mechanism is functioning accurately. The speed control circuit was set for 380 cycles at 830 knots giving a basic film speed of 1.224 inches per second.

The method of setting up the film speed control in flight places an extra burden on both the RO and pilot. The film speed control will be ineffective for low ground speeds and may possibly damage the film drive motors.. To prevent this, the pilot must "slew" his ground speed indicator to a safe recorder value, different from his normal lock-up setting. An automatic film-speed "on-off" control should be incorporated with limits determined by safe ground speed.

A shorted coupling capacitor in the video amplifier caused the CRT to fail. The new CRT arced and required replacement again. The third CRT operated satisfactorily.


FLIGHT #64
6-21-63
High Alt.
CREW: Johnson
Reader
GROUND SPD (KNOTS)
750
770
790
810
830
850
← END
ADETR MODE
START
Accel NTWK IN
WFO POT SET
900
700
500
300
100
ANTENNA POSITION (degrees)
UP
4
2
0
2
4
DOWN
DRIFT ANGLE (degrees)
L
4
2
0
2
4
R
DET METER 4(CPS)
0
100
200
300
400
500
DFT SIGNAL LEVEL
NOISE
← Time
150
140
130
120
110
100
90
80
1 D.F = 3.0 SEC

The average transmitted power this month was 10.5 watts and the average noise figure was 9.9 db. As of 27 June 1963, this system had 1007.6 non transmit hours and 278.1 transmit hours.

B ENVIRONMENTAL TESTS

The 9 g crash safety shock test was performed at Naval Research Laboratory. Prior to this test several calibration shock tests were performed. This crash safety test consisted of 3 shocks for 11 milliseconds duration. No system or unit failures occurred. Upon return the system was given to the Model Shop for crossed field amplifier modification.

Work proceeded on design of the antenna vibration fixture and high temperature oven.

C DESIGN EVALUATION

The following studies, previously described, were completed in this period and memos issued:

1. Computer Simulation of System Signal Processing (STM-123).

2. Addendum to Performance of IF Limiting as a Form of AGC (STM-122).

The addendum corrects the omission of the clutter contribution due to intermodulation of area targets caused by the limiter non-linearity. This correction indicates a clutter level higher than originally thought, but still quite acceptable, which agrees closely with the results from the computer simulation program.

Two studies were completed in this period, but are not yet reproduced as memos.

1. Effect of Relative Phase on the Range Resolution of 2 Point Targets. (STM-126)

The system range resolution depends on the relative RF phase between targets, since the returns from closely spaced targets will overlap in time. Destructive phase interference yields a different signal envelope than constructive interference, and the random nature of the phase can cause any value between the two extremes. This memo studies the effect, and finds resolution values for in-phase, out-of-phase, and average-phase conditions, for a typical CFA pulse shape. The receiver response and recorder response are also taken into account. The results are:

In-phase	22 feet
Random Average:	14 feet
Out-of-phase:	Approaches zero; depends on S/N ratio.

It is seen that on the average, a resolution comparable to, or less than, the transmitted pulse width should be obtained.

2. Feed-Forward (Logetronic) AGC Performance. (STM-127)

A feed-forward AGC was investigated as a possible means of reducing the dynamic range of input signals, and the performance compared tothat for IF limiting. The AGC was found to give no better results than the limiter in reducing the dynamic range; in fact, under some conditions, the performance is worse. For the optimum design, the results are very similar, but since the AGC is so much more difficult to mechanize, the IF limiting appears clearly preferable.

Other studies underway are:

1. Radar Range Equation and Signal/Noise Theory.

This study is aimed at developing equations and methods for calculating the system signal/noise performance. This includes

an idealized range equation derivation with the introduction of losses due to system imperfections. These include the effects of phase instabilities, unmatched bandwidth and pulse width, non-flat recorder response, correlator spatial filtering, correlator aperture stops, correlator weighting masks, non-rectangular antenna gain pattern, and noise-folding, along with the more obvious physical system losses. Also the noise statistics through the system are considered, from input to map output. It is also hoped (but not at all certain) that a theoretical basis can be established for the required S/N as a function of map appearance.

2. System Signal/Noise Calculations.

Based on the preceding theoretical study, the actual signal/noise across the map strip is being calculated. This varies drastically across the strip due to the antenna pattern, the recorder response, and the antenna angular instabilities. Also being calculated are all the losses mentioned in item 1. The end result will be a plot of actual signal/noise as it varies across the strip, for several different altitudes, for both area and point targets.

3. System Resolution Calculations.

The system resolution also varies as a function of range across the strip. This study is aimed at predicting the resolution across the strip, for both range and azimuth. Factors which affect resolution are recorder response, motion compensation, flight disturbances, pulse width and shape, receiver response, system jitter, phase instabilities, and, of course, the correlator. The end result of this study will be a plot of resolution as a function of range within the strip.

LABORATORY EVALUATION TESTS.

System tests during this period have been almost exclusively concerned with evaluating the cross-field amplifier flyable breadboard transmitter in the system. Also investigated briefly were the phase instabilities observed on a distant corner reflector reported in an earlier report, and attributed to the stalo. The cause has not yet been determined.

The following tests were performed on the cross-field transmitter to establish transmitter performance:

1. Peak power
   a. Tube #1 700 kw (developed anode-cathode short)
   b. Tube #2 800 kw
2. Pulse width
   a. 27-36 nanosecond at -3db points
   b. 50 nanosecond at approximately -60 db points
3. Pulse jitter
   a. TWT $<$ 1 nanosecond
   b. CFA $<$ 1 nanosecond
   c. Overall transmitter 2.5 nanosecond
4. Coincidence tracking between TWT and CFA RF pulses was demonstrated.
5. Phase instability (transmitter only)
   a. TWT $<$ 2° pk-pk
   b. Overall transmitter $<$ 4° pk-pk
6. Output was observed on a spectrum analyzer as an excellent spectrum.

D ANTENNA

ANTENNA #2

Antenna #2 has been assembled and electrically tested. The RF tests are being analyzed to determine the effects on the entire radar system. The antenna is in the process of sealing for pressure test and final inspection.

ANTENNA #3 AND SPARES

Honeycomb panels - One insert remains to be installed to complete the #3 panel. This insert is now on hand and will be installed during the week 1 July 1963. The remaining unmodified panel will be put in storage for possible later use.

Array Sticks - All Array sticks for Antenna #3 and the 6 spares modules have been bonded, cleaned, pressure tested, loads installed and are ready for assembly. All bonding fixtures will be put into storage after acceptance of all the modules.

Module Assemblies - The six module assemblies for Antenna #3 have been assembled and are undergoing the pre-solder electrical tests. Soldering has started. Four of the six spares module assemblies have been assembled and are ready for the pre-solder electrical tests. Completion of the spares modules will be held until completion of Antenna#3. Array sticks will be interchanged and rebonded as necessary to complete Antenna #3 first and then spares.

Power Dividers - All modified power dividers have been received. Electrical testing of these parts is underway and matched groups of dividers are being set up. Phase shifters will be set as close as possible to give equal phasing at all outputs.

SCHEDULE STATUS

Antenna #2 will be ready for delivery to the project on 3 July 1963, provided that no modifications on the power dividers are required.

Antenna #3 will be assembled and be ready for testing on 1 August 1963.

E RECORDER

GENERAL

The position of the new Lord shock mounts has been modified to simplify the pedestal changes.

The dynamic focus modification of recorder #4 will be accomplished at Westinghouse, Baltimore.

The first production high voltage power supply has been received from Kaiser and is undergoing tests.

Tests have continued on the repaired Amp power supply. This unit has operated very satisfactorily.

Vibration studies are continuing.

An investigation is being made of the feasibility of moving the speed calibration adjustment in the variable speed inverter to the outside of the recorder for ease of operation.

Parts were designed and fabricated to replace vibration mounts in favor of the Lord JA8350-7 & 8 Sandwich type mounts in recorder #5 and #6. These mounts were again used in testing the recorder #5 with the CRT in place instead of a pin-hole light source. An initial run was made with the recorder suspended one foot above the mounting surface of the shaker fixture to determine effects of the magnetic field. Then the recorder was attached to

the shaker fixture and vibrated similarly between 15 and 220 cps. Between 60 and 200 cps forcing frequency, recorder isolation was better than 93.5%. These films are being interpreted in terms of amounts of vibration present.

KAISER HIGH VOLTAGE SUPPLY

The first production unit of the four modified Kaiser High Voltage Supplies passed Phase I of the Acceptance Test. Phase II of the acceptance test will be a more precise measurement of the power supply parameters at Itek.

This production unit has operated reliably at the Kaiser plant for over 25 hours in the case, with no malfunctions. Continuous operating periods of more than 2 hours and intermittent cycling have been applied periodically to this high voltage supply.

The preliminary analysis of the data taken at the Kaiser plant indicates that the supply is regulating exceptionally well for temperature changes. For a 2 hour operating interval, the baseplate temperature rose to 62° centigrade in an ambient of 28° centigrade-maximum. The total drift of the ratio of ultor voltage to focus voltage from a cold start during this period was only 0.22%. After a 30 minute warm-up period, the total ratio change was only 0.033%. Further testing and evaluation of the test data will be made during the next report period.

A second high vltage supply is undergoing acceptance tests and will be shipped from the Kaiser plant on July 3, 1963.

AMP HIGH VOLTAGE POWER SUPPLY

The Amp High Voltage Supply has undergone varied and extensive laboratory bench tests during the past month. The unit

has operated reliably for more than 40 hours of continuous and intermittent duty cycle. After 5 hours of continuous operation the case temperature rose to 60° centigrade in an ambient temperature of 29° centigrade-maximum. The power supply is capable of exceeding the Amp Performance Specifications.

RESOLUTION

A technique for obtaining quantitative system resolution data is under study. The method currently used required visual evaluation of resolution test targets as observed on the spatial frequency bench, for the highest frequency recorded. It is recognized that factors other than resolution affect the final reading. The new method uses a neutral density wedge placed in the illuminated slit of thespatial frequency bench so that the height of each line representing a frequency component in the test target is modulated in height as a function of the percent modulation of the target. This display can be enhanced by photographic techniques so that the half-amplitude response as well as the limiting resolution can be determined.

Upon completion of some hardware for the bench, it is planned to use this technique in the study of the test films made while the recorder was being subjected to vibration analysis. We have also modified the resolution test set, or swept frequency generator, so that we can also obtain a set of discrete frequencies as well as a continuous changing frequency spectrum for study by means of this technique. This modification of the generator has been completed.

F **SWITCH TUBES**

Two new WX-3846 tail bite tubes have been fabricated, tested and packaged. One new WX-4554 (-11) dump tube has been fabricated and tested. Two other WX-4554 tubes are still in the process of being tested. The electrodes on all these tubes were intentionally flattened to retard erosion.

The WX-3846 was returned from the system section because of the inability to control the firing point of the tube with respect to the rf pulse. Examination of the tube showed excessive breakdown inside the tube at the intersection of the T-stub and the main guide.

A modulator obtained from the system section to drive the trigger electrode on the WX-4554 tubes is now being used to test the new tubes.

G **SYNCHRONIZER**

SYNCHRONIZER BOX - Range Mark Generator has been designed and breadboarded and will occupy the space formerly allotted to the Summing Network. A new layout in progress will adapt this new circuitry to use the previous Summing Network chassis.

FREQUENCY GENERATOR - Design of new circuitry is progressing.

H **TRANSMITTER**

FLYABLE BREADBOARD

All electrical tests are complete, with the results as tabulated in section C. These tests have been made with a plastic dome to observe transmitter operation in the SF_6 atmosphere. The following component problems remain:

1. Charging choke high voltage arc-over and excessive heating. New design is being procured.

2. TWT anode 30 KV power transformer arc-over (creepage). The unit is being modified. Substitutions have been made for laboratory testing. A new charging diode will be installed when mounting brackets are completed. An additional cooling duct has been provided for the TWT.

PROTOTYPE MODELS

New heat exchanger domes are being built by the subcontractor to replace the units that failed to pass mechanical inspection. The first new dome is due July 9.

Unit number 1 is being temporarily assembled with one of the rejected heat exchanger domes to the transmitter test program. All subchassis units have been electrically tested.

I DOPPLER FREQUENCY TRACKER

All the DFT's are completed and tested. The flight test system is being modified by the addition of one circuit, instrumentation to aid data evaluation, and slight mechanical rework.

J FIELD TEST EQUIPMENT

Since the last reporting period work has been progressing on all chassis affected by the changes required to incorporate the new azimuth resolution test generator and provide compatibility due to system modifications. The present status of each chassis affected is listed below:

1. Target Simulator - wiring on this chassis was started late due to a fabrication holdup. The chassis will be

completed and in composite test by 7/11/63. All 15 plug-in units required for this chassis are completed.

2. Frequency Converter - the modifications on this chassis are complete and electrical composite test has been completed.

3. Frequency Translator - all modifications on this chassis are complete. Electrical composite test is now in progress and will be completed by 7/3/63.

4. Control Panel - all modifications and electrical composite test are completed.

Because of the delay due to the target simulator preliminary tests with the radar system will not begin until 7/15/63.

All except two items of the standard test equipment listed on Exhibit "B", Section II, have been received, and delivered to the Government storeroom. The items missing are the Panoramic LF-2B Wave Analyzer which has a delivery promise date of 7/15/63, and the Microlab AC-10N Attenuator which was recently added to the list.

The Test Set Handbooks are now in progress again and will be reviewed by Engineering on 7/15/63. The books are now scheduled for delivery by September 1, 1963.

K MOTION COMPENSATION

The gain of the velocity compensation channel (including the accelerometer, the integrator and the frequency off-set generator) is critical as this compensation is entirely open loop. Initially gain was measured item by item. Two means of making an overall calibration were proposed in June and started.

One is by disturbing the autopilot in pitch and detecting the resulting error in the DFT by a phase detector. The hardware for this type of measurement, consisting of a .3 cps oscillator and a .3 cps phase detector, was completed.

The other method consists of putting a step acceleration into the accelerometer and recording the resulting frequency ramp on the recorder film. The feasibility of this method was demonstrated but sufficient accuracy of the angular change at the roll platform was not attained in the first measurement. The overall constant must be 20 ± .2 cps per ft/sec to satisfy system requirements, requiring a measurement of angle and frequency of 1% accuracy. The overall measurement was 15 ± 5 cps per ft/sec.